THE 3 DIMENSIONAL DISTRIBUTION OF CIRRUS

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ABSTRACT We just completed a large survey of the 1 RAS scanning data in the neighborhoods of Bright Star Catalog O and B stars with the purpose of mapping the distribution of the infrared cirrus, We find that within 400 pc the filling factor of interstellar gas with $n > 0.5$ cm^{-3} is approximately 15Y0. For densities greater than 1 cm^{-3} the density distribution function per logarithmic density interval follows a power law with index -1.25. When the detected cirrus "hotspots" are projected onto the galactic plane several large strut.tures emerge: the local hole or trough, the Taurus-Auriga clouds and the Oph-Sco-Cen region of recent and ongoing st ar formation.

INTRODUCTION

We were motivated by the compelling correspondence between the infrared cirrus, the 21 cm emitting gas and the material responsible for the extinction of starlight to explore the morphology of the diffuse interstellar medium using the IRAS data. Traditionally the distribution of interstellar matter has been studied using line of sight methods such as the color excesses of stars, interstellar absorption lines in stellar spectra and the surface brightness distribution of emission lines arising in the gas. Often a kinematic model is combined with spectral data to determine the distance to various emitting or absorbing gas parcels. With the IRAS data we were presented with a new opportunity to find the 3 dimensional distribution of the diffuse ISM because bright stars heat dust associated with the gas in their neighborhoods enough to be detected as extended far infrared emission nebulae. We call such nebulae cirrus hotspots.

A simple calculation shows that stars earlier than AO are luminous enough to cause cirrus hotspots in gas with $n = 1$ cm^{-3} at the IRAS detection level, approximately 5 Jy at 60 μm for an extended objec t against the galactic background. We thus c.hose all 1753 Bright Star Catalog stars located in regions surveyed by IRAS and not likely to be confused by IRAS with other BSC stars as our sample, and obtained 1-1) coadds of the scanning data crossing each star's position. About 35% of these stars showed possible evidence for extended far infrared emission, so we obtained 4° x 4° coadded images to see if the extended far infrared had the characteristics expected for a cirrus hotspot:

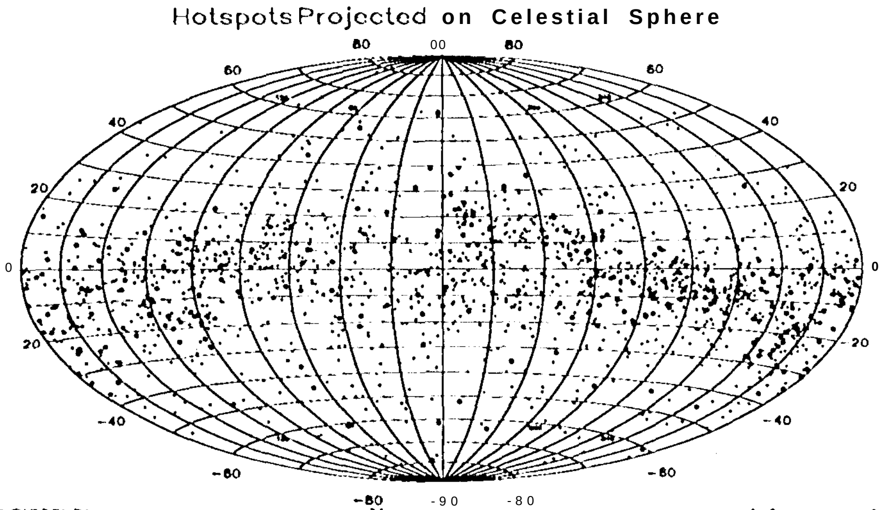

FIGURE 1 (in galactic coordinates) Large dots are stars with cirrus hotspots, small dots those without detections.

- in the direction of a known star,
- enhanced color temperature,
- temperature peaks at stellar position,
- extended on arcminute scales,
- F_{FIR}/F_{Bol} < 0.1 to eliminate H II regions.

Full details of the procedure are presented in our journal paper (Gaustad and Van Buren, 1993). The methodology follows closely that developed in the pilot study (Van Buren, 1989) and used by Buss, Gautier, Werner and Van Buren (1993), but differs in significant ways from the work of Murthy, Walker and Henry (1993).

MAPS

Using spectroscopic distances inferred from the BSC or SIMBAD, we can plot the 3-d distribution of stars with and without hotspots. These distances are not very accurate though, so we are awaiting publication of the Hipparcos results to produce a better set of maps than we present here. Figure I shows the positions of all program stars in the sky projected in galactic coordinates. Heavy dots represent stars with hotspots, small dots those with no detected FIR nebulae. in Figure II we show the distribution of hotspots projected onto the galactic plane. 302 hotspots are represented in these maps.

FILLING FACTOR

If the program stars are distributed in an unbiased manner with respect to the cirrus, a point discussed in some detail in our PASP paper, then the fraction of stars showing hotspots is equal to the fraction of space containing dust with sufficient density to yield an observable hotspot. By constructing complete

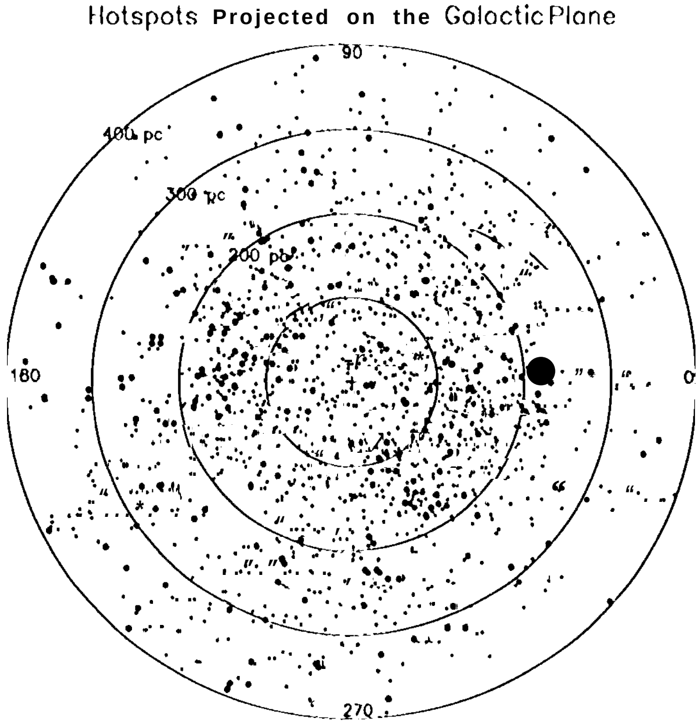

FIGURE 11 (projected on the galactic plane) Towards l= 180 are the Taurus clouds at $d \approx 150pc$, the Oph-Sco-Cen region is near l= 300, and in the close neighborhood of the sun there is a minimum in the hotspot distribution.

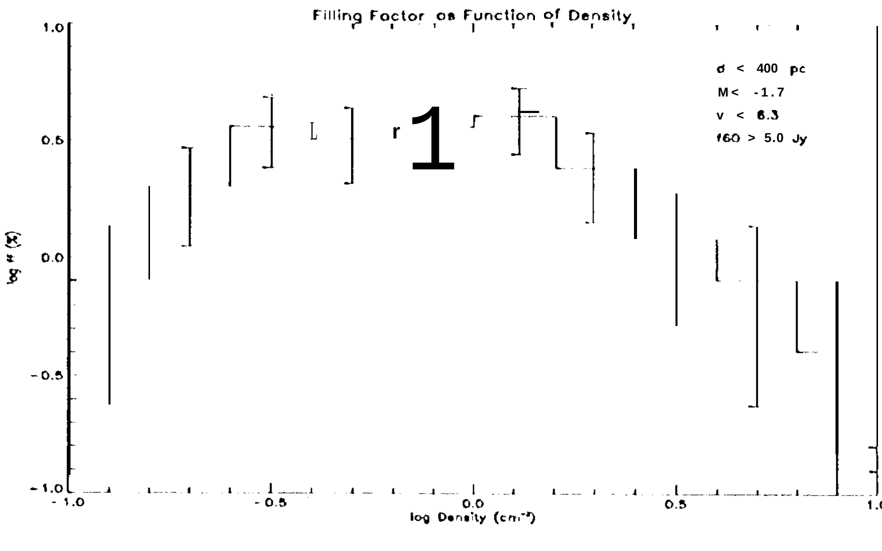

FIGURE III The density distribution function as determined from a complete subsample of our survey. At densities > 1 a power law with slope -1.25 is a good fit. We are not sensitive below densities of $0.5\ cm^{-3}$.

subsamplcs of the program stars on the basis of visual magnitude (governing inclusion in the BSC) and far infrared fluxes (governing detection by IRAS) wc find that the filling factor of diffuse ISM with n >0.5 cm^{-3} is $14.6 \pm 2.4\%$ within *400* pc.

Referring to Figure 111, where the density distribution function of the dust-bearing medium is presented for a complete subsample of stars with d <400 pc, nolc that a power law $d(\log f)/d(\log n) = -1.25$ *is an* adequate representation for n > 1 cm'^{3}, Because this is so steep, the sample size is not large enough to probe densities much above 10 ctn^{-3}, but in any case no more than a fcw percent of interstellar space could contain material at higher densities, subject of course to the validity of our assumptions.

Combining our derived filling factor of 15% for the diffuse ISM, an extrapolation of the power law behavior at higher densities (which can only account for ≈1% of the volume), and the estimates by Reynolds (1 991 and references therein) that the medium with *electron* density ≈ 0.2 cm^{-3} comprises about 20% of the volume, wc note that a volume fraction ≈ 0.64 appears to be void of any but the most tenuous gas or dust. The actual value of this fraction depends on to what extent, the diffuse ionized gas and the low density cirrus overlap. With this overall picture in mind it is interesting to view figure 7 of Bregman, Kelson and Ashc (1 993), where 21 cm channel maps show the best match for an ISM with a volume fraction 0.57 to 0.75 in holes.

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